PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Plain Bearings

We, THE GLACIER METAL COMPANY LIMITED, of 368, Ealing Road, Alperton, Wembley, Middlesex, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in high speed journal bearings such as are encountered, for example, in gas turbines and other applications.

In such high speed bearings it is essential that metal-to-metal contact between running surfaces should be avoided and friction losses reduced to a minimum. The use of oil, grease or other liquid or semi-liquid medium for the lubrication of such bearings is either impracticable or undesirable, and the present invention is specifically concerned with improvements in high speed bearings in which under normal operating conditions metal-to-metal contact is prevented by the maintenance of a film or layer of air or gaseous medium between opposed relatively moving surfaces of the bearing. During starting or stopping, or due to variations in load conditions, running surfaces may come momentarily into contact and damage to the bearing surface may result.

The present invention has for its object to provide an improved high speed bearing of the kind referred to whereby at any region where clearance between the running surfaces is reduced by the load applied, the pressure of the gaseous medium will be automatically increased for the effective maintenance of a film or layer of the gaseous medium separating the running surfaces, and whereby, in the event of momentary metal-to-metal contact, the bearing is safeguarded against damage.

It is known to provide a bearing surface faced with or incorporating a solid lubricating substance, such as poly-tetra-fluoro-ethylene, a chloro-fluoro-carbon or mixture of chloro-fluoro-carbons, molybdenum disulphide, tungsten disulphide or the like, the solid lubricating substance safeguarding the bearing surface against damage in the event of metal-to-metal contact in the absence of oil or other lubricant provided that speed and load are restricted to suitable limits.

It has also been proposed to provide a bearing comprising a sleeve having a bearing surface provided with at least three circumferentially and substantially uniformly spaced axial recesses to each of which a fluid, which may be mercury, water or any other kind of fluid adapted for reducing friction, is individually metered through an orifice plug with the object of maintaining the annular clearance between the bearing surface and the shaft, said recesses being of indeterminate cross-sectional form.

According to the present invention, a plain bearing of the kind referred to is provided with at least three circumferentially spaced grooves or groove formations extending in the bearing surface parallel, or substantially parallel, to the axis of the bearing, each groove tapering in cross-section in the direction of rotation of the journal from a maximum depth to zero depth, means associated with each groove being provided for individually metering air or other gaseous medium under pressure thereto, and the bearing surface being faced with or incorporating a solid lubricating substance.

The function of the circumferentially extending tapering grooves or groove formations is to provide for increase of pressure at any region where clearance between the running surfaces is reduced by the load applied, and thereby to maintain during all normal operating conditions a film or layer of the compressed air or gaseous medium between and separating the running surfaces. The solid lubricant at or incorporated in the bearing surface serves to safeguard against damage if, when starting or stopping, or due to variations in load conditions, the run-

ning surfaces should come momentarily into contact.

Preferably five grooves are circumferentially spaced symmetrically about the axis of the bearing.

The grooves may extend substantially the length of the bearing and terminate short of the extreme ends thereof. Alternatively, three or more circumferentially spaced groove formations may be employed, each formation consisting of a number of axially spaced grooves of tapered cross-section.

The groves of alternate or successive groove formations may be staggered axially. In all arrangements embodying multiple groove formations, the compressed air or other gaseous medium is supplied to the grooves of each formation through individual metering means so that the supply of air or gaseous medium under pressure is metered to separate circumferentially extending zones of the bearing.

If the direction of rotation of the journal is constant, the grooves may be wedge-shaped in cross-section, i.e., tapering from a maximum depth at one end of the section to zero depth at the other, the reduction in depth being in the direction of rotation of the journal and the compressed air or gaseous medium being introduced at the part of maximum depth after passing through the associated metering means.

For use with a journal rotatable in either direction, the grooves are of maximum depth at a middle position of the cross-section and taper to zero depth at both ends of the section.

In the case of journal bearings having a flange at one or both ends to function as a thrust bearing, the grooves in the bearing, or certain of the grooves, may be extended to the flanged ends of the bearing and radially outwards in the face of the flange.

The pressure of the air or gaseous medium may vary inversely with respect to the speed of rotation. At starting, a high pressure of, for example, 200 lbs. per square inch may be required, but when an operating speed of, for example, 30,000 r.p.m. has been attained, a pressure of 20 to 50 lbs. per square inch may be sufficient.

The invention is hereinafter described, by way of example, with reference to the accompanying diagrammatic drawings, in which:—

Fig. 1 is a longitudinal section illustrating one embodiment of plan bearing according to the invention;

Fig. 2 is a cross-section of the bearing bush;

Fig. 3 is a cross-section showing a modified groove formation for use with a journal rotatable in either direction;

Figs. 4 and 5 are views similar to Fig. 1 illustrating modifications; and

Fig. 6 is a part sectional plan view corresponding to Fig. 5.

In carrying the invention into effect according to one embodiment and as illustrated in Figs. 1 and 2 of the accompanying diagrammatic drawings, a plain journal bearing in the form of a metallic bush 1 supporting a journal 3 rotatable in the direction indicated by the arrow in Fig. 2, and having its bearing surface faced with, or incorporating, a solid lubricant such as polytetra-fluoro-ethylene, is formed with at least three, and preferably five, circumferentially spaced grooves 2 symmetrically arranged about the axis of rotation. Each groove 2 is of tapered formation in cross-section having a maximum depth, for example, up to twice the radial clearance between the journal 3 and the bearing surface, at one end of the section, and tapering to zero depth at the other end of the section, the reduction in depth being in the direction of rotation of the journal 3. The axial length of each groove 2 preferably is rather less than the length of the bearing 1 so that at the ends of the bearing the grooves are blind. Air or other gaseous medium under pressure is admitted to the deeper part of each groove 2 through separate metering means, e.g., a small hole or passage 4, from an annular channel 5 in a bearing housing 6, said channel 5 communicating with a pipe 7 connected to a source of air or gaseous medium under pressure and provided with a shut-off cock 8 and pressure gauge 9. The total circumferential extent of the grooves is preferably from 10% to 25% of the bore circumference.

As shown in Fig. 3, the bearing may be adapted for use with a journal rotatable in either direction by providing the grooves 2 of maximum depth at a middle position in the cross-section tapering to zero depth at both ends of the section.

In a modification, as illustrated in Fig. 4, a journal bearing in the form of a bush as above described is formed with groove formations 10 arranged symmetrically about the axis of rotation, each groove formation comprising a number of axially spaced tapered grooves 2 of the cross-sectional form shown in Fig. 2 or Fig. 3, the grooves of each formation being supplied with air or gaseous medium under pressure through individual holes or passages 4 communicating with annular channels 5*a* supplied from a common pipe or passage 7. The grooves 2 of the alternate or successive groove formations 10 may be staggered axially as shown in Fig. 4 so that together they are substantially co-extensive with the greater part of the length of the bearing.

In the application of the invention to a journal bearing in the form of a sleeve 1 having a flange 11 at one end adapted to

function as a thrust bearing, the sleeve, as shown in Figs. 5 and 6, may be formed with three or more circumferentially spaced symmetrically arranged grooves of a form shown in Fig. 2 or Fig. 3, and said grooves are extended to the flange 11 and radially outwards in the face of the flange, the radially extending parts 2*a* of the grooves preferably terminating short of the periphery of the flange 11. A sleeve provided with a flange at each end may have the grooves extended in a similar manner in the face of both flanges.

In the application of such bearings to gas turbines, air or other gaseous medium under a high pressure of, for example, 200 lbs. per square inch at starting, may be supplied from a compressed air bottle or other suitable source, while under normal running conditions, when a comparatively low pressure of 20 to 50 lbs. per square inch is adequate, the air or gaseous medium at this pressure may be obtained from the main engine compressor stage.

The means for individually metering the air or other gaseous medium to the several grooves or groove formations may, for example, comprise a separate pump and feed line for each groove or groove formation, such an arrangement, however, being relatively expensive and therefore only applicable when the question of cost is unimportant. In general, it is preferred to supply the air or gaseous medium from a common pressure source, such as a compressor or reservoir, such as a bottle, and to meter the supply of air or gaseous medium under pressure to each groove or groove formation through a small hole or passage 4 which imposes such resistance to the flow of the air or gaseous medium that the pressure in the respective groove or groove formation is between 1/10th and one-half of the supply pressure, usually about 1/3rd. If the journal under the influence of a load moves closer to the bearing surface at one point, escape of air from the respective groove or groove formation in the neighbourhood of this point is thereby restricted to a substantially greater degree than by the respective hole or passage 4, and increased pressure will, as a result, build up in the respective groove or groove formation until the journal is restored to a nearly central position in the bearing. The said holes or passages 4 preferably are disposed to communicate with the grooves 2 at an intermediate position in the length thereof.

It will be understood that the invention is not limited to the particular embodiments hereinbefore described. For example, any other suitable metering means may be arranged intermediate the source of supply under pressure and the grooves in any other suitable manner.

The invention is applicable to plain bearings faced with, or incorporating, any suitable solid lubricant or combination of solid lubricants, and is of particular utility in connection with bearings for any purpose where it is necessary or desirable to operate under conditions of high speed without the employment of oil, grease or other liquid or semi-liquid lubricant.

What we claim is:—

1. A plain bearing of the kind referred to, wherein at least three circumferentially spaced grooves or groove formations are provided to extend in the bearing surface parallel, or substantially parallel, to the axis of the bearing, each groove tapering in cross-section in the direction of rotation of the journal from a maximum depth to zero depth, means associated with each groove being provided for individually metering air or other gaseous medium under pressure thereto, and the bearing surface being faced with, or incorporating, a solid lubricating substance.

2. A plain bearing according to Claim 1, wherein five grooves are circumferentially spaced symmetrically about the axis of the bearing.

3. A plain bearing according to Claim 1 or Claim 2, wherein the grooves extend substantially the length of the bearing and terminate short of the extreme ends thereof.

4. A plain bearing according to Claim 1, wherein three or more circumferentially spaced groove formations are provided, each formation consisting of a number of axially spaced grooves tapering in cross-section in the circumferential direction.

5. A plain bearing according to Claim 4, wherein the grooves of alternate or successive groove formations are staggered axially.

6. A plain bearing according to Claim 4 or Claim 5, wherein the air or other gaseous medium under pressure is supplied to the grooves of each formation through individual metering means.

7. A plain bearing according to any of the preceding claims, wherein the grooves are wedge-shaped in cross-section and taper from a maximum depth at one end of the section to zero depth at the other, the reduction in depth being in the direction of rotation of the journal and the air or gaseous medium under pressure being introduced at the part of maximum depth after passing through the associated metering means.

8. A plain bearing according to any of the preceding Claims 1 to 6, wherein the grooves are of maximum depth at a middle position in the cross-section and taper to zero depth at both ends of the section.

9. A plain bearing according to any of the preceding claims having a flange at one or both ends to function as a thrust bearing,

wherein the grooves in the bearing, or certain of the grooves, are extended to the flanged ends of the bearing and radially outwards in the face of the flange.

10. A plain bearing according to any of the preceding claims, wherein the solid lubricating substance consists of poly-tetra-fluoro-ethylene, a chloro-fluoro-carbon or a mixture of chloro-fluoro-carbons, molybdenum disulphide, tungsten disulphide or the like.

11. The improved plain bearing, substantially as hereinbefore described with reference to Figs. 1, 2 and 3 of the accompanying diagrammatic drawings.

12. The improved plain bearing, substantially as hereinbefore described with reference to Fig. 4 of the accompanying diagrammatic drawings.

13. The improved plain bearing, substantially as hereinbefore described with reference to Figs. 5 and 6 of the accompanying diagrammatic drawings.

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PROVISIONAL SPECIFICATION

Improvements in or relating to Plain Bearings

We, THE GLACIER METAL COMPANY, LIMITED, of 368, Ealing Road, Alperton, Wembley, Middlesex, a British Company, do hereby declare this invention to be described in the following statement:—

This invention relates to plain bearings, and is particularly concerned with improvements in journal bearings of the kind wherein the bearing surface is faced with, or incorporates a solid lubricating substance, such as poly-tetra-fluoro-ethylene, a chloro-fluoro-carbon or mixture of chloro-fluoro-carbons, molybdenum disulphide, tungsten disulphide or the like.

The anti-friction properties of such solid lubricants enable a plain bearing assembly to function without damage in the absence of oil or other lubricant provided that the operating conditions, particularly as regards speed and load, are restricted to suitable limits.

For high speeds, such as are encountered, for example, in gas turbines, it is essential that the running surface should not come into actual contact with one another. In gas turbines and other applications involving operating conditions of high speed, lubrication by the use of oil, grease or other liquid or semi-liquid medium is for various reasons either impracticable or undesirable.

The present invention has for its object to enable a bearing of the kind referred to to be effectively employed under conditions of high speed without the use of oil, grease or other liquid or semi-liquid lubrication.

According to the present invention, a plain bearing of the kind referred to is provided with at least three grooves or groove formations in the bearing surface, such groove or groove formations extending circumferentially and tapering in the direction of rotation from a maximum depth to zero depth, and means associated with each groove or groove formation is provided for individually metering air or other gaseous medium under pressure thereto.

The pressure of the air or gaseous medium may vary inversely with respect to the speed of rotation. At starting, a high pressure of, for example, 200 lbs. per square inch may be required, but when an operating speed of, for example, 30,000 r.p.m. has been attained, a pressure of 20 to 50 lbs. per square inch may be sufficient. The function of the circumferentially extending tapering grooves or groove formations is to provide for increase of pressure at any region where clearance between the running surfaces is reduced by the load applied, and thereby to maintain during all normal operating conditions a film or layer of the compressed air or gaseous medium between and separating the running surfaces, the solid lubricant at or incorporated in the bearing surface serving to safeguard against damage if, when starting or stopping or due to variations in load conditions, the running surfaces should come momentarily into contact.

If the direction of rotation is constant, the circumferentially extending grooves can be wedge-shaped in section, i.e., tapering from a maximum depth at one end to zero depth at the other, the reduction in depth being in the direction of rotation and the compressed air or gaseous medium being introduced at the end of maximum depth after passing through the associated metering device. For rotation in either direction, the circumferentially extending grooves would be of maximum depth at a middle position in their length and would taper to zero depth at both ends.

More than three, and preferably five, symmetrically, or substantially symmetrically, arranged grooves or groove formations may be employed and may extend parallel to, or substantially parallel to, the axis from end to end of the bearing, although such grooves preferably would not extend to the extreme edges. Alternatively, three or more symmetrically, or substantially symmetrically, arranged groove formations may be em-

ployed, each formation consisting of a number of parallel circumferentially extending tapered grooves which may be of **V**, **U** or other suitable cross-section.

Alternate or successive parallel grooves in such groove formations may be staggered circumferentially. In all arrangements embodying multiple groove formations, however, compressed air or other gaseous medium is supplied to the grooves through individual metering devices arranged so that the supply of air or gaseous medium under pressure is separately metered to separate circumferentially extending zones of the bearing.

In the case of journal bearings having a flange at one or both ends to function as a thrust bearing, the grooves in the bearing, or certain of the grooves, may be extended to the flanged ends of the bearing and radially outwards in the face of the flange.

In carrying the invention into effect according to one embodiment, a plain journal bearing in the form of a metallic bush having its bearing surface faced with, or incorporating a solid lubricant, such as poly-tetra-fluoro-ethylene, is formed with at least three, and preferably five, circumferentially extending grooves symmetrically arranged about the axis of rotation. Each groove is of tapered formation having a maximum depth at one end which may be, for example, up to twice the radial clearance between the journal and the bearing surface and tapering to zero depth at the other end, the reduction in thickness being in the direction of rotation. The width of each groove preferably is rather less than the length of the bearing so that at the ends of the bearing the grooves are blind. Air or other gaseous medium under pressure is admitted to the deeper end of each groove through a separate metering device so that the grooves are not connected in parallel to a single pressure delivery pipe. The grooves may extend parallel to the axis of the bearing or may be inclined or curved relative to the axis so as to be, for example. helically disposed. The total circumferential length of the grooves may be, for example, 10 to 25% of the bore circumference.

In a modification, a journal bearing in the form of a bush as above described is formed with three or more, preferably five, groove formations arranged symmetrically about the axis of rotation, each groove formation comprising a number of parallel circumferentially extending tapered grooves and each groove formation being supplied with air or gaseous medium under pressure through an individual metering device. Alternative or successive parallel grooves or groove formations may be staggered circumferentially, in which case separate metering devices may be arranged for the supply of air or other gaseous medium under pressure to the groups of grooves which are in axial alignment or substantially so.

In the application of the invention to a journal bearing in the form of a sleeve having a flange at one end adapted to function as a thrust bearing, the sleeve may be formed with three or more circumferentially extending symmetrically arranged grooves as before described and said grooves may be extended to the flanged end of the sleeve and radially outwards in the face of the flange, the radially extending parts of the grooves preferably terminating short of the periphery of the flange. A sleeve provided with a flange at each end may have the grooves extended in a similar manner in the faces of both flanges.

In the application of such bearings to gas turbines, air or other gaseous medium under a high pressure of, for example, 200 lbs. per square inch at starting, may be supplied from a compressed air bottle or other suitable source, while under normal running conditions, when a comparatively low pressure of 20 to 50 lbs. per square inch is adequate, the air or gaseous medium at this pressure may be obtained from the main engine compressor stage.

The means for individually metering the air or other gaseous medium to the several grooves or groove formations may, for example, comprise a separate pump and feed line for each groove or groove formation, such an arrangement, however, being relatively expensive and therefore only applicable when the question of cost is unimportant. In general, it is preferred to supply the air or gaseous medium from a common pressure source, such as a compressor or reservoir, such as a bottle, and to meter the supply of air or gaseous medium under pressure to each groove or groove formation through a small orifice or nozzle which imposes such resistance to the flow of the air of gaseous medium that the pressure in the respective groove or groove formation is between 1/10th and one-half of the supply pressure, usually about 1/3rd. If the journal under the influence of a load moves closer to the bearing surface at one point, escape of air from the respective groove or groove formation in the neighbourhood of this point is thereby restricted to a substantially greater degree than by the respective orifice or nozzle, and increased pressure will, as a result, build up in the respective groove or groove formation until the journal is restored to a nearly central position in the bearing.

The orifices or nozzles may be in the form of small holes in the bearing, preferably disposed centrally of the grooves or groove formations and communicating with each other and with the source of supply by

means of an annular groove in the housing. Alternatively, suitable restricting nozzles may be arranged intermediate the source of supply and the grooves or groove formations in any other suitable manner.

It will be understood that the invention is not limited to the particular embodiments hereinbefore described. For example, the invention is applicable to plain bearings faced with, or incorporating, any suitable solid lubricant or combination thereof, and the invention is also applicable to bearings for any purpose where it is necessary or desirable to operate under conditions of high speed without the employment of oil, grease or other liquid, or semi-liquid lubricant.

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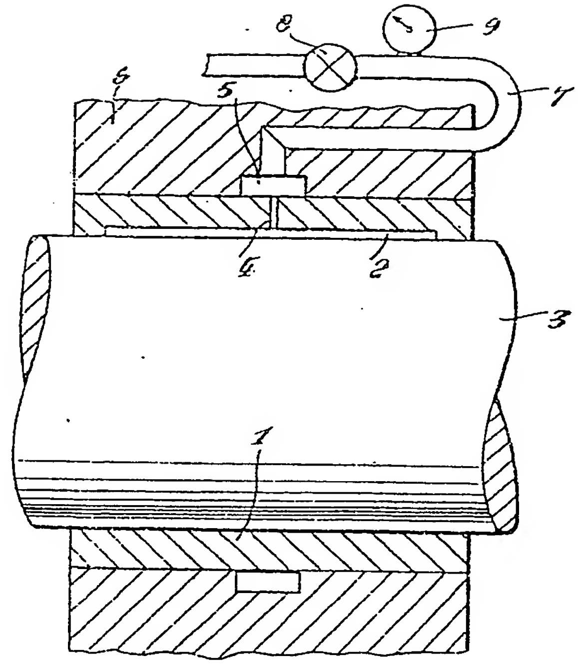
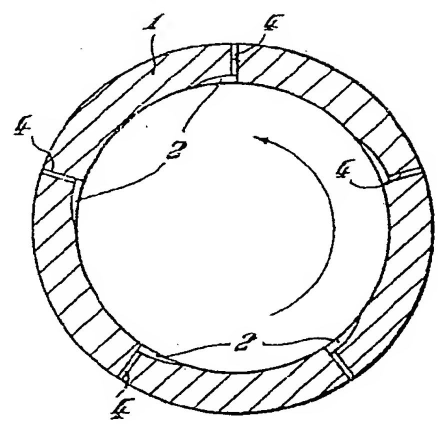


Fig.1.

Fig.2.



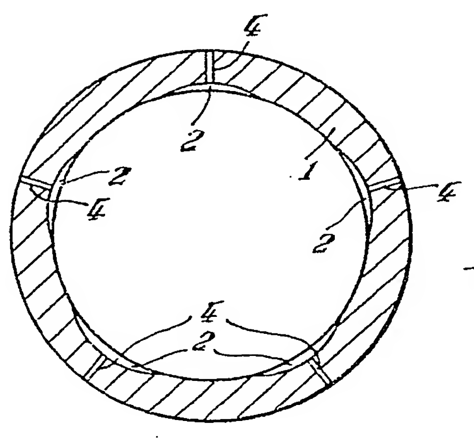


Fig.3.

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SHEETS 1 & 2

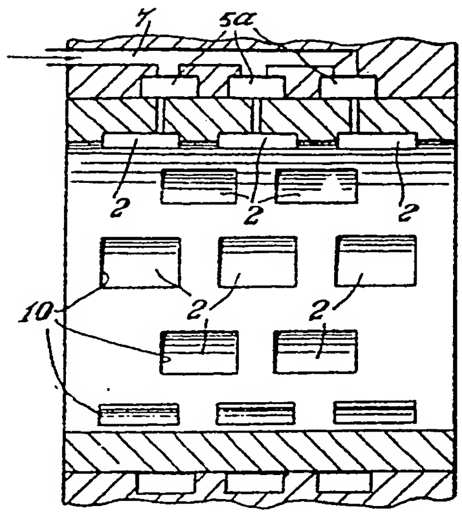


Fig. 4.

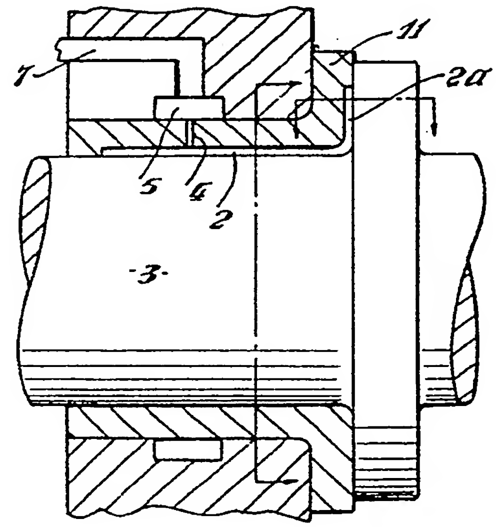


Fig. 5.

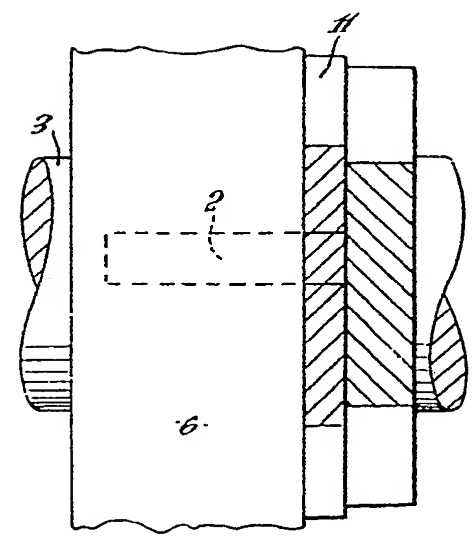
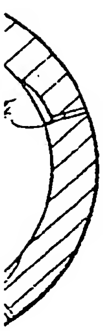


Fig. 6.



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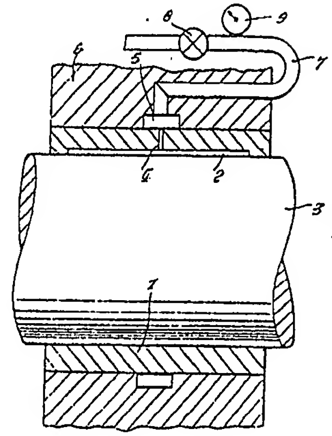

Fig. 1.

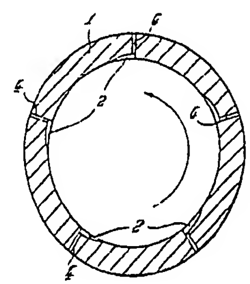

Fig. 2.

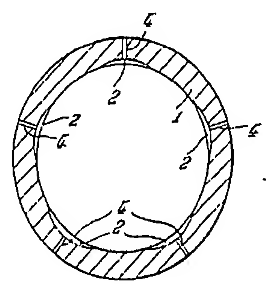

Fig. 3.

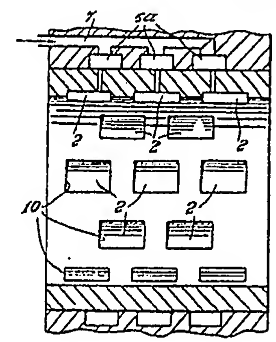

Fig. 4.

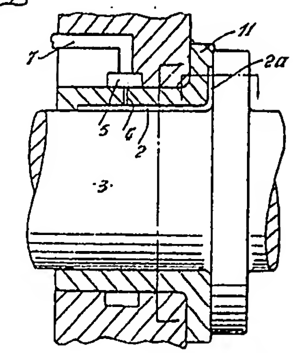

Fig. 5.

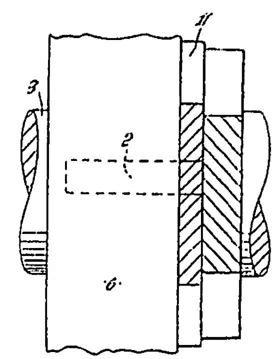

Fig. 6.